

Executive Summary

This Phase 1 Design Report for the Mississippi River Reintroduction into Bayou Lafourche project represents the first major evaluation of new and refined alternatives of the Phase 1 Engineering and Design approved by the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) Task Force. This work evaluates alternatives that meet the project purpose, defined as follows:

Maximize the Mississippi River connection to Barataria-Terrebonne Basins to nourish and protect the marsh through the reintroduction of fresh water, sediments, and nutrients. The proposed project has added purposes of ensuring long-term freshwater supply to communities and industries served by the Bayou Lafourche Freshwater District by limiting salt water intrusion and enhancing water quality.

This report presents analyses for evaluation of an array of project alternatives. These alternatives were systematically screened, qualitatively and quantitatively, resulting in a short list of five alternatives. These alternatives are recommended to be further evaluated in the 30 percent design. The 30 percent design evaluation will be conducted concurrently with the environmental review process National Environmental Policy Act. At its conclusion, one project alternative will be recommended for detailed design and construction.

Overview

To formulate and evaluate alternatives, a general approach was devised to characterize, group, define, and evaluate the broad range of possible alternatives that meet project objectives. A goal of this evaluation was to review a combination of previously and newly proposed potential alternatives. The alternatives were then logically screened to narrow the range of options to a short list that more closely reflect the overall objectives of the project.

To define the alternatives, the basic categories of features or components that comprised each alternative were identified. These basic categories are discussed below.

Conveyance System

The conveyance system is composed of Bayou Lafourche and other major new channels constructed as part of the overall system. Conveyance system project components that were included in the evaluation as part of the Phase 1 design effort are the bayou's cross section (including potential dredging extent) and water depth profile along each reach, alternative bypass channel routes around Donaldsonville, and major hydraulic structures that influence capacity and water levels of the system.

Diversion Structures

The diversion structures include the facilities necessary to convey fresh water from the Mississippi River into Bayou Lafourche or the bypass channel. These include pump stations located along the river, intake piping, discharge piping, and sediment control facilities. Sites

for the diversion structures included locations at Donaldsonville and Smoke Bend, upstream of Donaldsonville.

System Control and Monitoring

Control and monitoring systems include all systems deployed to control or stabilize water levels during times of pump shutdown, hazardous spill containment, or storm events. These systems generally include deployable weirs, monitoring stations, and monitoring/control linkages to the pump station.

Infrastructure, Utility, and Site Modifications

The alternatives considered will require some level of modification to the various constructed features depending on the alternative. Some require land to be acquired for a new bypass channel and associated improvements. Other impacts to existing roads, bridges, utilities, and other existing infrastructure vary depending on the particular features of the alternatives.

The initial list of potential alternatives was quite large because of the possible combinations of the following physical variables:

- Specific route of the main conveyance channel
- Diversion location and flow rates
- Dredged channel cross section
- Allowable water level

Because of these variables, the Phase 1 analysis focused on refining the general conveyance route and hydraulic capacity of the system, leaving more detailed evaluation of components such as the pump station, for the 30 percent evaluation.

Early in this initial Phase 1 evaluation, several prominent issues became apparent:

1. The number of possible alternatives associated solely with channel geometry is substantial. A systematic methodology for evaluation was required to efficiently reduce the number of potential options based on flow, channel dimensions, and water level profile.
2. Costs attributed to dredging the bayou dominate the overall costs of all the alternatives.
3. Demonstrating the relationships among raised water levels in Bayou Lafourche, property impacts, project alternative conveyance capacity, and costs is vital to environmental and policy-level decisionmakers for subsequent phases of the project.

In light of the broad range of project alternatives, it was necessary to formulate an approach that characterized a potential channel system (depth and cross section along the channel profile, plus other key hydraulic features) and identified the diversion capacity of that system. After characterization of the alternatives, planning-level cost estimates were developed to allow comparisons among project alternatives. Relative costs were used as a quantitative screening mechanism to eliminate alternatives that were clearly not cost effective. The cost estimates developed for the screening were conceptual planning level estimates and not suitable for budgeting purposes.

Evaluation of Alternatives

Formulation and Analysis of Conveyance Alternatives

The conveyance system features used to define alternatives revolve around the following factors: route, hydraulic structures, target water levels, dredge template, and the potential bypass channel depth. By combining the basic features with other alternative options (i.e., variations in bypass channel excavation criteria, modifications to the Union Pacific Railroad crossing, and inclusion of a bayou check structure immediately upstream of Palo Alto Bridge), 144 alternatives were characterized for further evaluation.

For the initial screening of alternative alignments in the Phase 1 design, the hydraulics of the upstream 56 miles of Bayou Lafourche, from the Mississippi River to Lockport, were evaluated. The conveyance capacity, channel size, effect of different dredge templates, target water levels, and alignment alternatives were evaluated with hydraulic models. Figure ES-1 shows the primary study area for the screening of conveyance options in the Phase 1 design.

This initial evaluation was conducted using Hydrologic Engineering Center-River Analysis System (HEC-RAS), a one-dimensional backwater model developed by the U.S. Army Corps of Engineers. Alternatives for evaluation by the model were characterized by the following criteria. Key features describing each conveyance alternative are described in the following subsections.

Target Water Levels

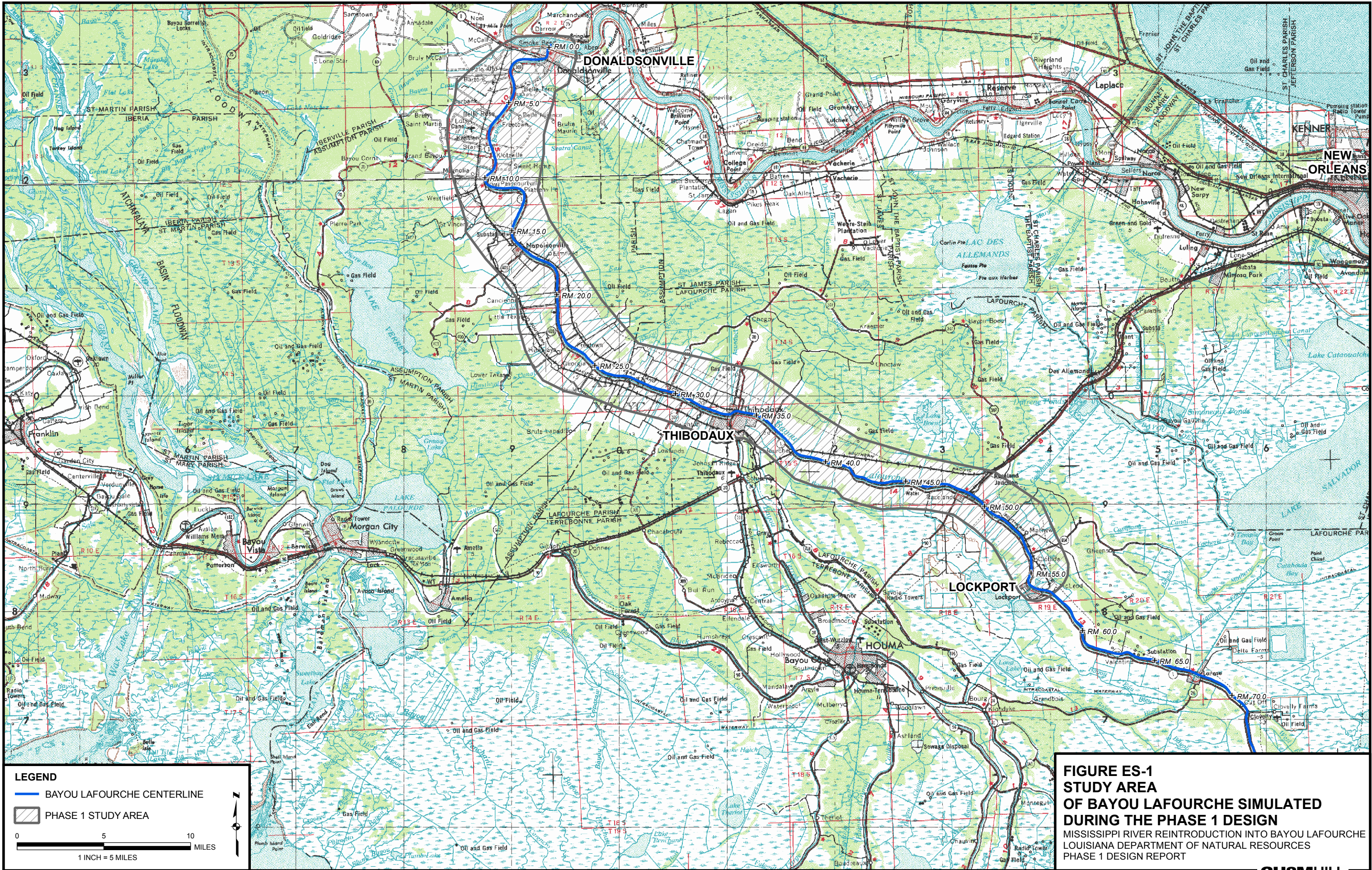
To evaluate hydraulic capacity, assumptions were made about the project's affect on water surface level throughout the bayou. As part of the alternative formulation process, the design team considered a wide range of potential flows. Flow limits were achieved by developing alternatives that varied by target water level. Three not-to-exceed water level profiles were developed and termed target water levels. The allowable diversion flows were developed by modeling the average existing water level in Bayou Lafourche, historical mean low, and mean Mississippi River elevations at Donaldsonville (extrapolated linearly down to sea level at the Gulf of Mexico) for higher target water levels.

Dredge Templates

Increasing the capacity of the bayou depends on two factors: raising the water level and dredging. For alternative formulation, cross-sectional areas were varied by dredge template. For this Phase 1 design analysis, three different channel geometries were proposed: no dredge, 2-foot dredge, and 8-foot dredge (as measured by the depth from the bottom of the existing channel invert). The three geometries were applied in various combinations, resulting in seven different dredge template scenarios. Dredging was confined to the segment of the bayou between Donaldsonville and Lockport.

Construction of New Bypass Channel

A new bypass channel around Donaldsonville beginning at Smoke Bend on the Mississippi River is included in the alternatives. The new bypass channel would be approximately



13,500 feet long with a trapezoidal design section of varying widths (depending on the design flow). Two channel excavation configurations were developed: shallow and deep.

The shallow excavation configuration was developed to minimize the excavation and land acquisition requirements for the bypass channel. The water surface of the shallow bypass channel configuration was placed near the existing land surface downstream of the railroad crossing at the Smoke Bend diversion facility location and then translated along the bypass alignment at the design slope. Excavation requirements for the channel were developed using the resulting topography along the alignment. Because the excavation was minimized, a drop structure will be required at the confluence to introduce the flows into the bayou.

The deep excavation would include greater excavation and land acquisition, but would eliminate the need for energy dissipation at the confluence (drop structure) with Bayou Lafourche near the Palo Alto Bridge.

Hydraulic Structures

The Donaldsonville or Smoke Bend bypass alternatives also have two key hydraulic features in the Bayou Lafourche reach upstream of the Palo Alto Bridge. For the Donaldsonville route alternatives, the existing railroad bridge near the levee would significantly restrict increased flow. For those alternatives, two optional features were included in the conveyance alternative: either the railroad bridge was to be replaced to lessen the hydraulic restriction, or the bridge would be left unmodified.

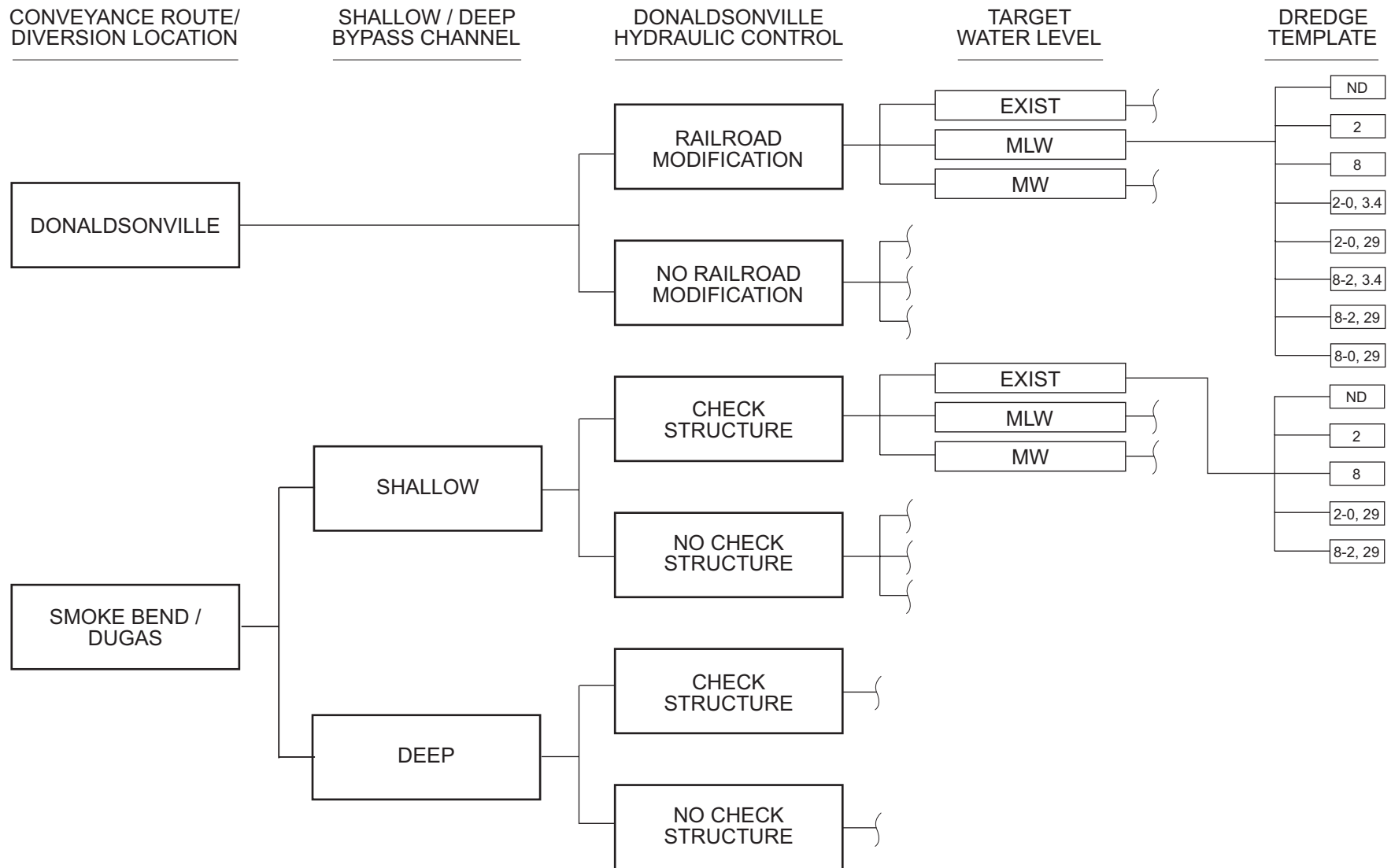
A small dam located just upstream of the confluence of the bypass channel and Bayou Lafourche was included as an alternative feature for some of the conveyance alternatives. The purpose of the dam (referred to as a check structure) is to eliminate backwater affects into Donaldsonville from higher downstream water levels.

HEC-RAS Analysis

Each alternative cross-sectional geometry, dredge templates, hydraulic structures, and overall conveyance route were input to the HEC-RAS model. Flow was varied to meet the not-to-exceed target water levels. Therefore, for each alternative, a maximum flow was derived to meet the controlling target water level. Dredging volumes based on the dredge templates were also calculated using the HEC-RAS model. This approach resulted in an efficient computational approach to formulating alternatives and an excellent method to draw comparisons between the alternatives.

The detailed hydraulic modeling evaluated 69 of the possible 144 alternatives derived from a combination of alignments, target water surfaces, dredging, and improvements (check structures and railroad bridge modifications) used to determine the allowable flows that would meet target water levels. The 69 alternatives were the remainder after the application of the first set of filter criteria (discussed further below).

A diagram presenting the methodology of combining the project features to formulate the various conveyance alternatives is presented on Figure ES-2. Combining the flowchart options suggests that 144 alternatives could be considered when using all seven dredge templates, plus the no-dredge option.



**FIGURE ES-2
CONVEYANCE ALTERNATIVES
CHARACTERIZATION DIAGRAM**
MISSISSIPPI RIVER REINTRODUCTION INTO BAYOU LAFOURCHE
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Comparison of Alternatives

Qualitative Screening

Alternatives were compared in a step-wise fashion using eight qualitative and quantitative screening criteria. Figure ES-3 illustrates this generalized comparison process and sub-divides the screening approach into three main groups of criteria. Comparison Criteria 1 through 3 and Criteria 4 through 6 focus on a more qualitative evaluation where specific limitations or criteria were used to screen alternatives. Reasons for screening included not being cost effective (e.g., alternatives with an extremely high ratio of dredge quantity to diversion flow), restrictive to flow, or did not make sense (e.g., dredging in Donaldsonville for Smoke Bend alignments). Costs were not specifically needed to make these determinations.

Figure ES-4 outlines the screening criteria basis and illustrates how the 144 alternatives were screened down to 19 for quantitative screening. Comparison Criteria 7 and 8 on Figure ES-3 evaluate the quantitative cost effectiveness of the remaining alternatives. The number of alternatives screened out at each step of the process is shown on Figure ES-4.

A key consideration in the screening process was the expected impacts from increased water levels. Detailed photographic surveys of structures coupled with Geographic Information System-based water level contouring were used to assess impacts. These studies indicate that the increase in water level from mean low water (MLW) to mean water (MW) would cause a significant increase in impacted property and structures.

The MLW level rise is less than 1.5 feet throughout the Donaldsonville area and about 5 feet in the Thibodaux area. The MW level rise was approximately 1 to 2 feet higher than the MLW through both cities.

Detailed structures and property inventory in the local Donaldsonville and Thibodaux areas led to the conclusion that a water level rise in Bayou Lafourche should be limited 1.5 feet in Donaldsonville (downstream of the railroad bridge) and 3.0 feet in Thibodaux. These increased water levels are less than the MLW elevation in Thibodaux and about equal to MLW in Donaldsonville. Table ES-1 shows a sample structure impact inventory of the local areas near Donaldsonville and Thibodaux.

TABLE ES-1

Local Structure Impacts and Inundated Property

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	Donaldsonville ^a		Thibodaux ^b		
	MLW	MW	3-foot Rise	MLW	MW
Structures	7	17	20	36	47
Property (acres)	6	20	11	19	25

^aUpstream of the Palo Alto Bridge.

^bWithin 4 miles downstream of weir.

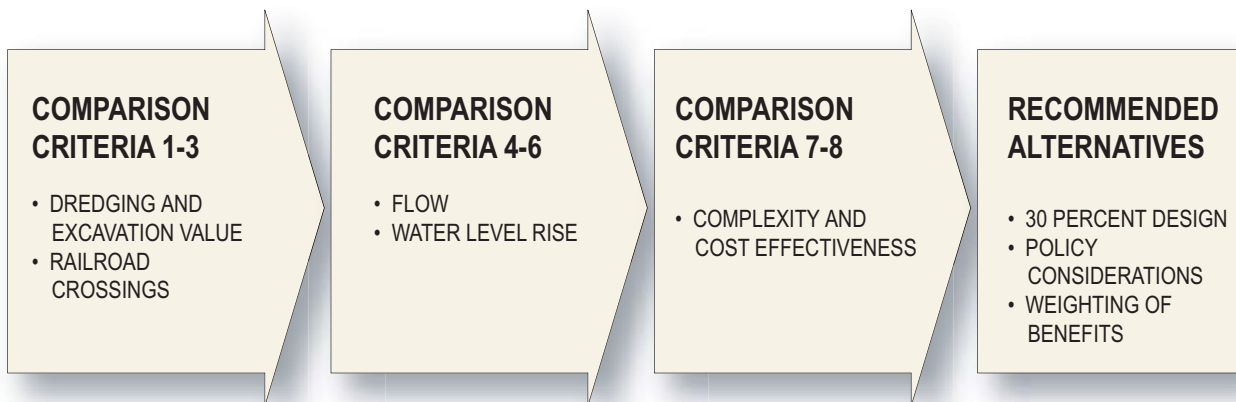


FIGURE ES-3
PROCESS FOR
COMPARING ALTERNATIVES
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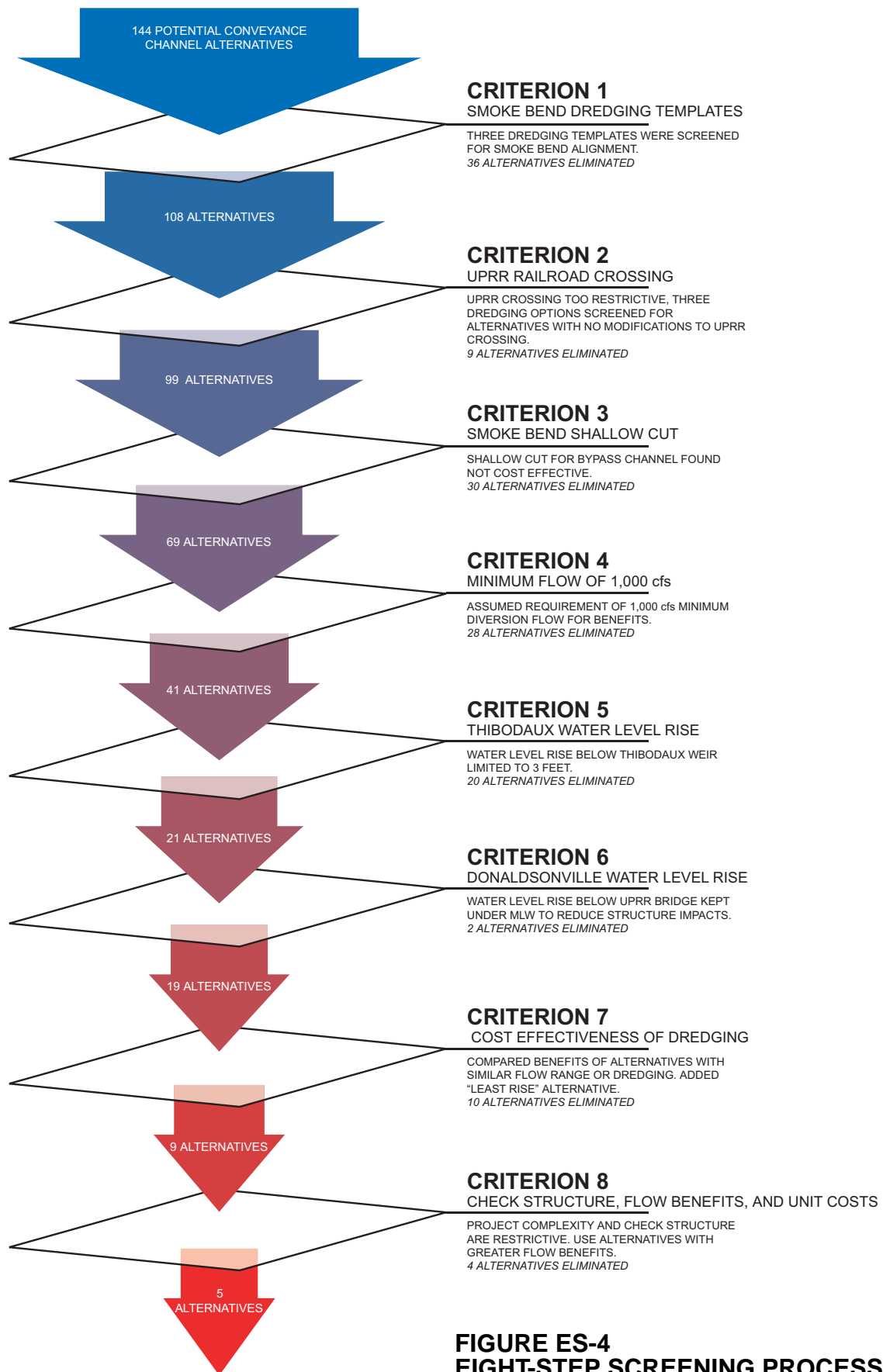


FIGURE ES-4
EIGHT-STEP SCREENING PROCESS
CONVEYANCE CHANNEL ALTERNATIVES
MISSISSIPPI RIVER REINTRODUCTION INTO BAYOU LAFOURCHE
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Quantitative Screening

The development of cost estimates, as a quantitative screening step at the Phase 1 design stage of the project, was completed to compare cost differences among alternatives in Criteria 7 and 8 on Figure ES-4. The costs presented do not represent total construction, land acquisition, or capital costs. Therefore, they are not suitable for use in developing funding projections or total cost budget requirements. The costs developed were planning-level cost estimates prepared in accordance with the guidelines of the Association for the Advancement of Cost Engineering International for Class 4 estimates.

Costs were developed for the following alternative features:

- Dredging of Bayou Lafourche
- Constructing new bypass channel
- Bypass channel siphons
- Highway 1 crossing and drop structure at Bayou Lafourche
- Union Pacific Railroad crossing in Donaldsonville
- Deployable weirs in bayou
- Bulkheads
- Structure impacts
- Check structure with pump station at confluence
- Utilities relocation
- New diversion facility at Smoke Bend
- Modifying the Donaldsonville facility

Pump station costs for the diversion facility were based on a similar configuration in operation at Donaldsonville (riverside pump station with discharge over the levee). Costs were adjusted depending on flow capacity requirements of the specific alternative. The diversion structures and other components will be refined in the 30 percent evaluation, after the overall conveyance alternatives (e.g., route, target water level, dredge volume, and flow capacity) are screened to a reasonable number.

After completing cost estimates for the range of alternatives remaining after screening Criterion 6, the quantitative screening analysis was performed. The further reduction in alternatives to carry forward into the 30 percent design was based on cost comparisons of alternatives relative to the features described in the following subsections.

Comparison of Alternatives with Similar Dredging Requirements

For this level of analysis, alternatives with similar dredging requirements but different flow were screened to select the more efficient alternatives. Because the amount of dredging translated directly into higher costs, the advantage to the project was to carry forward those projects with the greatest flow at a similar dredging volume. Unit costs were developed for each of the 19 remaining alternatives and plotted versus flow. The more cost-effective alternatives in each dredging range were carried forward.

Least Rise (Water Level Rise) Alternative

The impacts of water level rise led to the development and analysis of a least rise alternative consisting of a 1,000-cubic foot per second (cfs) diversion and an 8-foot dredge template

from Donaldsonville to Lockport. The hydraulic analysis of this alternative showed the lowest water level rise at 1,000 cfs, and, therefore, the least impact on structures.

The unit cost for this alternative was the largest of all the remaining alternatives because of the dredging required, and was, therefore, eliminated from further consideration. However, presenting the alternative had the value of showing the cost of reducing water level impacts as much as possible at the low flow threshold of 1,000 cfs.

Comparison of Alternatives by Complexity and Flow

The last step in the quantitative screening process for the remaining alternatives was to review the alternatives against project features and cost effectiveness. This approach was used because certain alternatives required additional complex features but benefited a small segment of the bayou. For example, protecting the residents in Donaldsonville from a rise in water level with a check structure and pump station added costs and only benefited the Donaldsonville residents.

When the unit cost of alternatives was similar, the relative benefit of additional flow was used to separate alternatives. The expectation of the project was that more flow would translate into greater downstream benefits. The alternatives with the greatest flow for similar unit costs were carried forward.

Analysis of Remaining Alternatives

The remaining five alternatives were summarized on a common unit cost versus flow diagram to delineate trends. As shown on Figure ES-5, the remaining alternatives follow a clear trend line of increasing unit cost with increasing flow. Each of these remaining alternatives has a measure of structure impacts that have been incorporated into the total project cost.

Of the remaining five alternatives, three are for the Donaldsonville alignment and two are for the Smoke Bend alignment. The largest flow considered for the project was 2,000 cfs and is only associated with a Smoke Bend alignment.

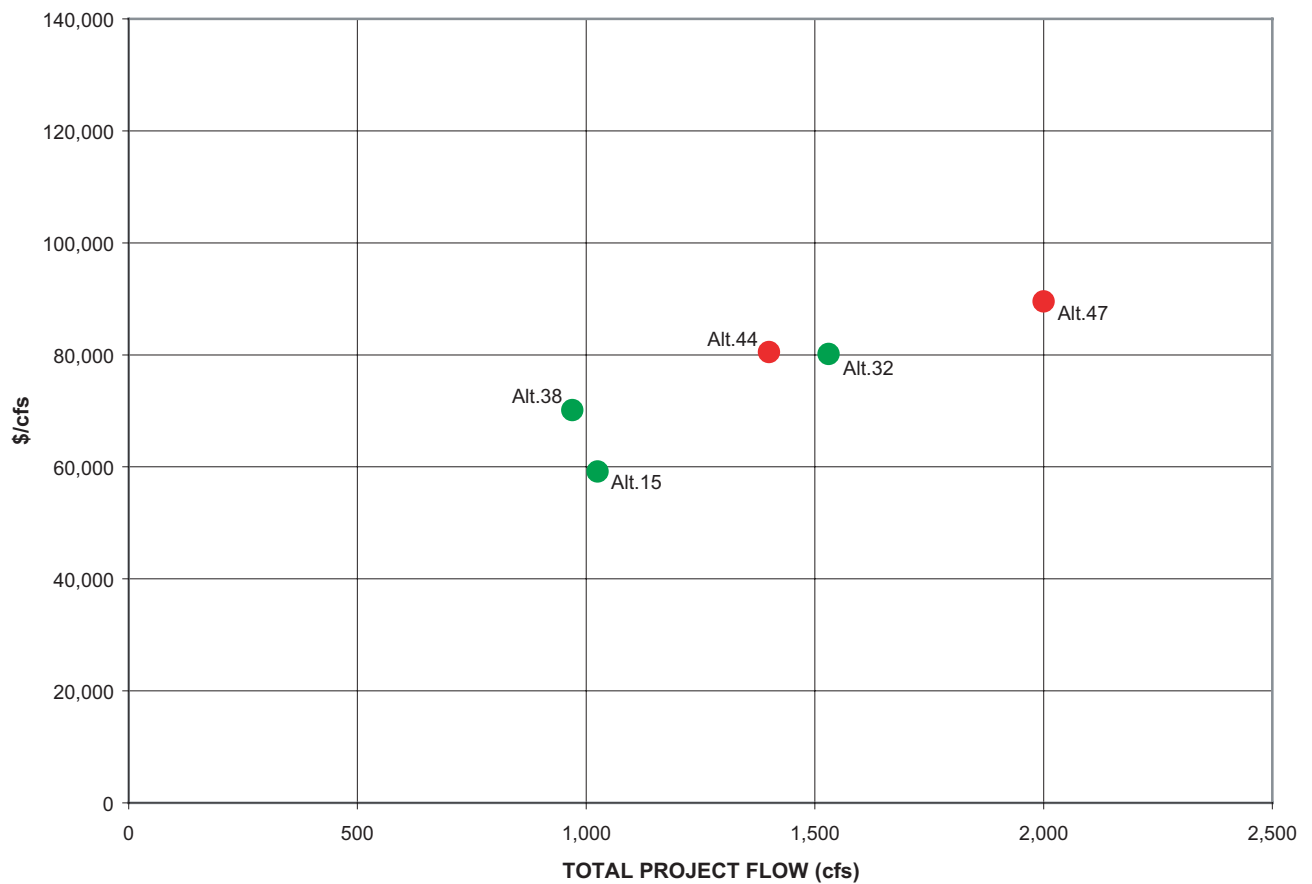
Selection of Recommended Alternatives

Selection of Short-list Alternatives for Further Design Analysis

The alternatives shown on Figure ES-5 were those that remained following the eight-step screening process and evaluation for cost efficiency (cost per cfs). These five alternatives combine to provide flows ranging from 1,000 to 2,000 cfs. None of the remaining alternatives include the use of a check structure, and two of the alternatives require the replacement of the Union Pacific Railroad Bridge.

Two of the alternatives require dredging to 8 feet for all or a portion of Bayou Lafourche and, therefore, might have additional bridge stability impacts. Bridge stability impacts will be evaluated in the 30 percent design phase. A similar situation exists for bulkhead costs.

Although some bulkhead costs have been included in the 8-foot dredging alternatives for bank stability, the full extent of bulkhead areas cannot be shown until the additional geotechnical work for the 30 percent design report is completed.



LEGEND

- DONALDSONVILLE ALTERNATIVES
- SMOKE BEND ALTERNATIVES

**FIGURE ES-5
COST-EFFICIENCY PLOT OF
REMANING ALTERNATIVES**

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Following are the key decisions that will allow the remaining five alternatives to be reduced to one:

1. Should the design flow rate be 1,000, 1,500, or 2,000 cfs?
2. Should the Smoke Bend Bypass be used, or should the original channel through Donaldsonville be used? If the selected flow is greater than 1,500 cfs, Smoke Bend must be used.
3. Should the Union Pacific Railroad crossing be modified? If the higher water level (MWL) upstream of the bridge is acceptable and the 1,000-cfs flow is selected, the bridge would not require modification. If the Donaldsonville alignment is selected and a flow greater than 1,000 cfs is selected, a new bridge would be required.

Summary of Recommendations

A recommended group of alternatives is presented that was used to define a range of potential diversion flows and project costs. This short list of selected alternatives represents the perspectives of the design team with regards to possible alternatives that could proceed into the 30 percent design.

The screening process resulted in alternative costs ranging from approximately \$70,000,000 to \$179,000,000. The unit costs varied from about \$60,000 per cfs to \$90,000 per cfs.

Table ES-2 shows the specific attributes of the five remaining alternatives and the potential flow expected to be achieved through development of the project. Figure ES-6 shows the range of water levels for the Donaldsonville and Thibodaux areas.

The results in this report provide a basis to Louisiana Department of Natural Resources, U.S. Environmental Protection Agency (EPA), and the rest of the project team to proceed with discussions regarding project flow, benefits, and budget.

Integration of Design Activities with Environmental Documentation

As the design activities on the project proceed in the 30 percent design stage, it is important to closely coordinate the design and environmental documentation work. The EPA has selected a consultant for the environmental documentation activities. The design team should meet with the consultant, Louisiana Department of Natural Resources, and EPA regularly to review the various activities of each team and coordinate information exchange.

Incorporation of Policy-level Decisions

Assumptions were made by the design team to develop the recommended short list of alternatives for the project. Figure ES-5 illustrates that the short list falls on a continuously increasing trend in costs versus flow of potential alternatives for the project. Budgetary and project impacts must be integrated with the environmental benefits as the project proceeds. Refinements to the remaining alternatives are possible in the 30 percent design and selection of a single alternative should be made before starting the final design.

TABLE ES-2

Recommended Alternatives for Further Study in the 30 Percent Design

Mississippi River Reintroduction into Bayou Lafourche – Phase 1 Design Report

Alternative No.	Alignment Alternative	Donaldsonville Railroad Crossing	Dredge Template	Maximum Target Water Level	Potential Cost (nearest \$ million)	Project Flow (cfs)	Cost per cfs (\$)
15	BL	NM	2-0@RM29	MW	61	1,025	59,150
32	BL	M, NB	8-2@RM29	MLW	123	1,530	80,150
38	BL	M, NB	2-0@RM29	MLW	68	970	70,100
44	SB	NM	2-ALL	MLW	113	1,400	80,500
47	SB	NM	8-ALL	MLW	179	2,000	89,500

Notes:

BL = Bayou Lafourche

M = Modified

NB = New Bridge

NM = Not Modified

RM = River Mile

SB = Smoke Bend

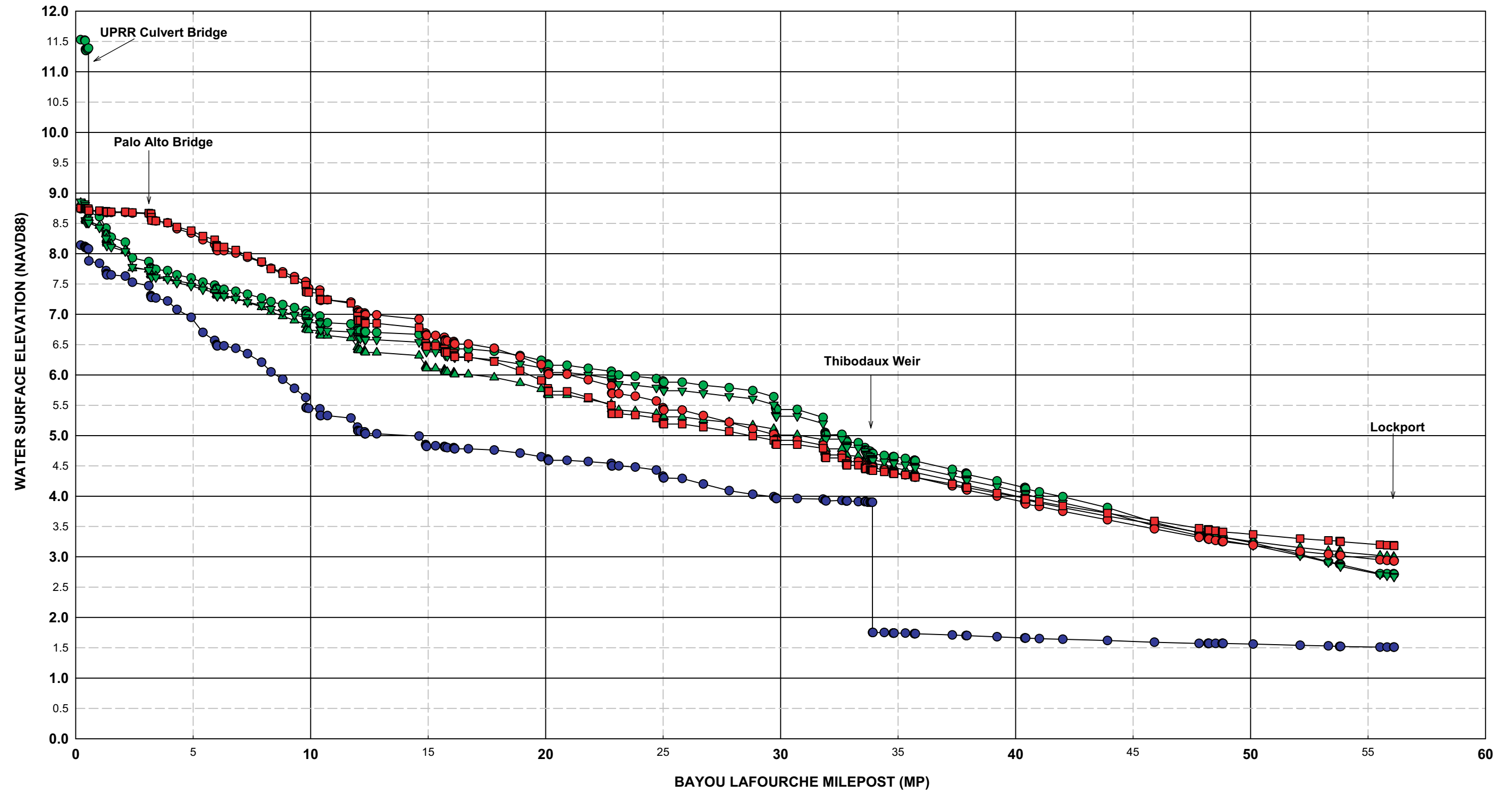


FIGURE ES-6
WATER SURFACE PROFILES
FIVE REMAINING ALTERNATIVES
BAYOU LAFOURCHE CHANNEL
 MISSISSIPPI RIVER REINTRODUCTION INTO BAYOU LAFOURCHE
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Subsequent to the development of the five final alternatives and during the review of the Draft Final Phase 1 Report, the Louisiana Department of Natural Resources and EPA requested that Alternative 20 and the least rise alternative be included in the set of remaining alternatives. The incorporation of these two alternatives was a policy-level decision to include additional alternatives with reduced water level rise, compared with the five recommended alternatives previously discussed.

Each of the two alternatives, 20 and least rise, has a diversion flow of about 1,000 cfs. Figure ES-7 shows the comparison of the water level rise for all seven of the alternatives. Both Alternative 20 and the least rise alternative reduce the projected rise in water level (resulting from the five final alternatives) by between 0.5 and 1.5 feet. The least rise alternative results in a water surface that is up to 2 feet lower than existing upstream of the Thibodaux weir, but this could be managed with check structures.

Table ES-3 shows the major attributes of the seven alternatives recommended by Louisiana Department of Natural Resources and EPA to be carried into the 30 percent design.

TABLE ES-3

Recommended Alternatives for Further Study in the 30 Percent Design
Mississippi River Reintroduction into Bayou Lafourche – Phase 1 Design Report

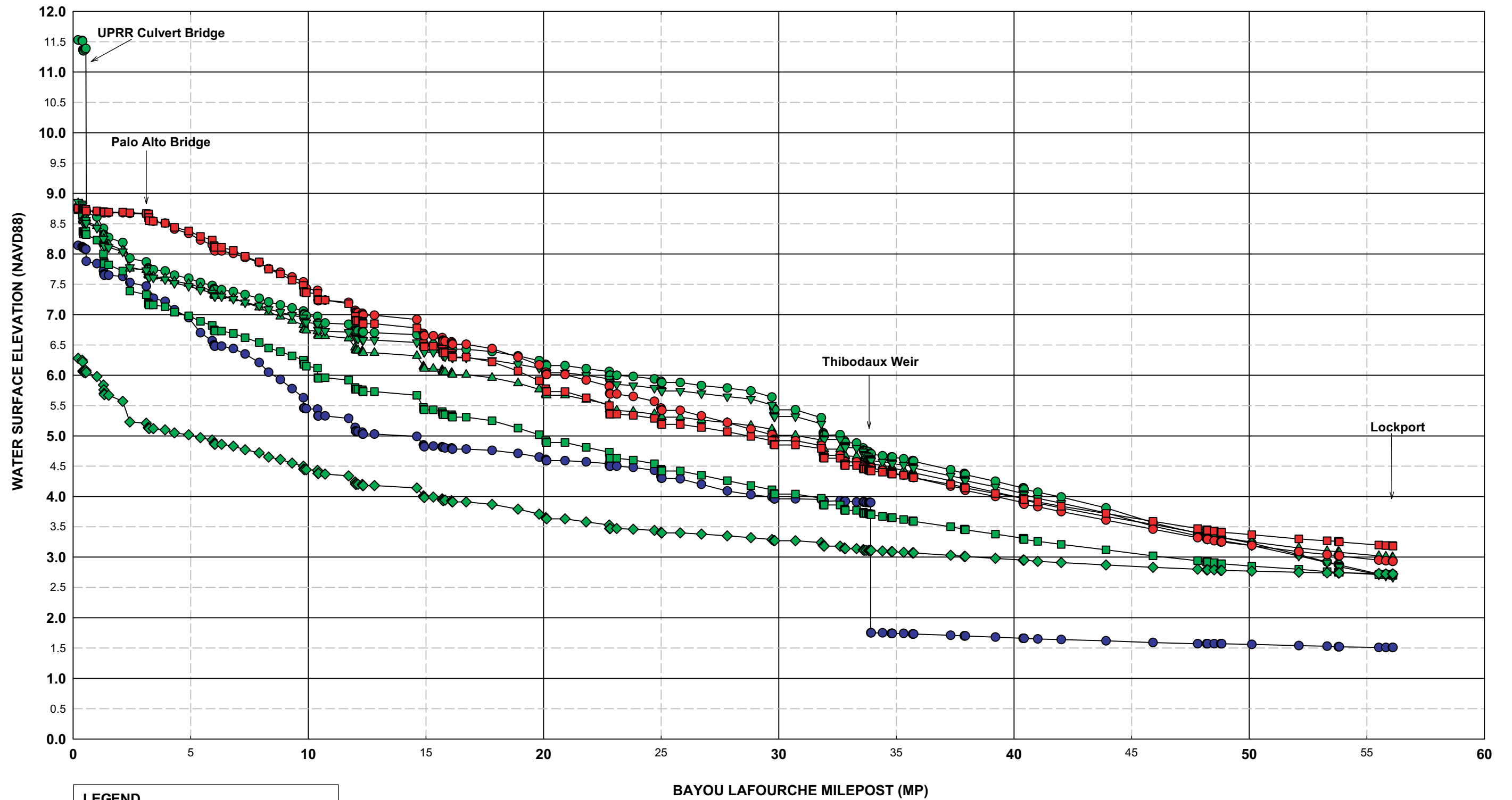
Alternative No.	Alignment Alternative	Donaldsonville Railroad Crossing	Dredge Template	Maximum Target Water Level	Potential Cost (nearest million \$)	Project Flow (cfs)	Cost per cfs (\$)
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32	BL	M, NB	8-2@RM29	MLW	123	1,530	80,150
38	BL	M, NB	2-0@RM29	MLW	68	970	70,100
44	SB	NM	2-ALL	MLW	113	1,400	80,500
20	BL	M, NB	2-ALL	MLW	89	1,020	87,300
47	SB	NM	8-ALL	MLW	179	2,000	89,500
Least Rise	BL	M, NB	8-ALL	E	121	1,000	120,600

Note:

E = Existing Water Level

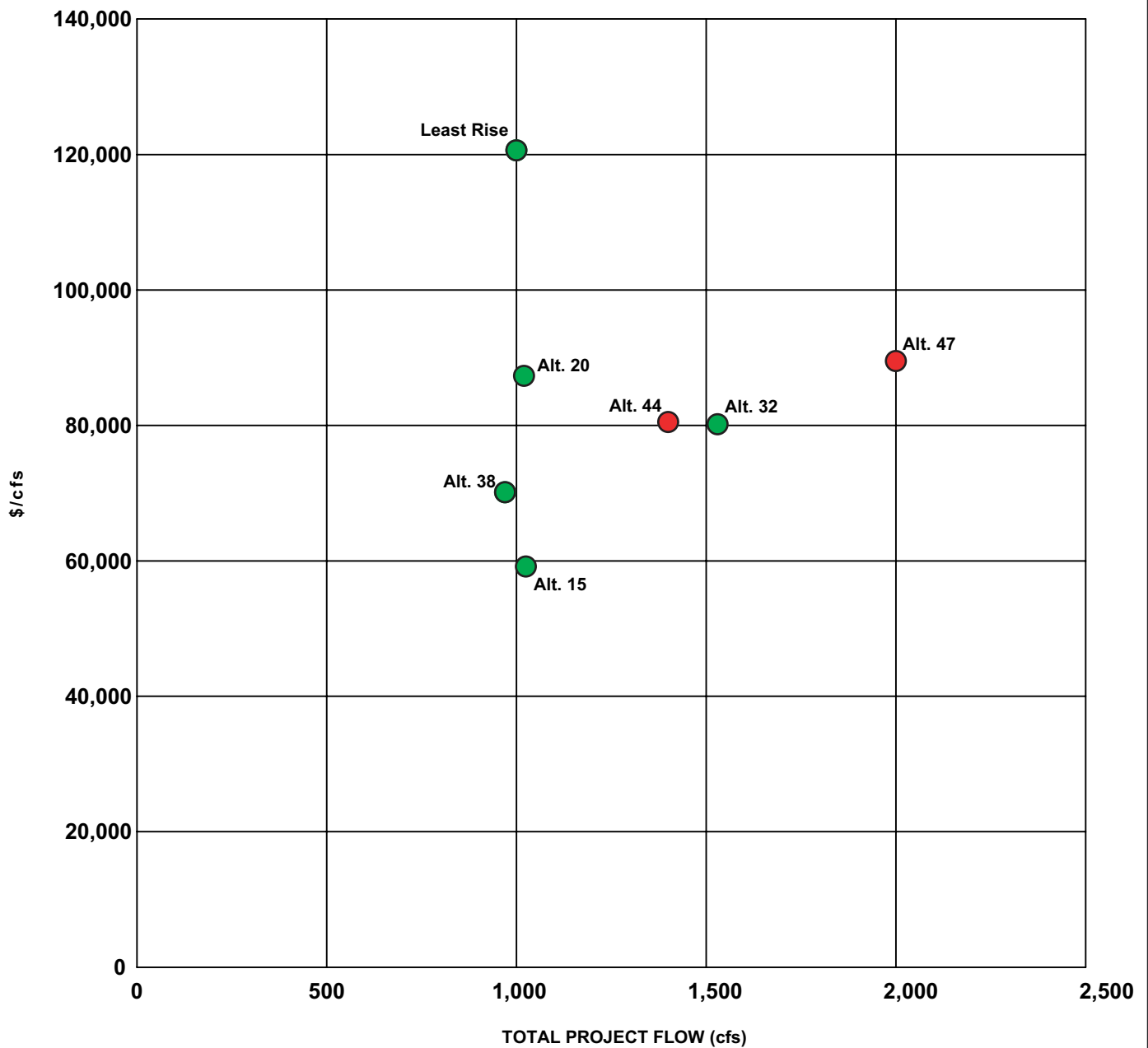
The unit costs range from \$59,000/cfs to \$121,000/cfs. Figure ES-8 shows a graphical representation of the alternatives unit cost compared with diversion flow. The trend of the five recommended alternatives from the detailed screening process is up-and-to-the-right showing slightly increasing unit costs for the added flow. With the addition of Alternatives 20 and the least rise, four alternatives have about 1,000 cfs with unit costs between \$59,000/cfs and \$121,000/cfs.

Each of the seven alternatives will be evaluated in the 30 percent design for engineering and costs. A final recommended alternative will be prepared as part of the 30 percent design report.



- LEGEND**
- Existing
 - ALT. 15, 2'-0" RM29, 1,025 cfs, BL
 - ALT. 20, 2'- All, 1,020 cfs, BL
 - ▲— ALT. 32, 8'-2" RM29, 1,530 cfs, BL
 - ▼— ALT. 38, 2'-0" RM29, 970 cfs, BL
 - ◆— Least Rise, 8'- All, 1,000 cfs, BL
 - ALT. 44, 2'- All, 1,400 cfs, SB
 - ALT. 47, 8'- All, 2,000 cfs, SB

FIGURE ES-7
WATER SURFACE PROFILES
SEVEN REMAINING ALTERNATIVES
BAYOU LAFOURCHE CHANNEL
 MISSISSIPPI RIVER REINTRODUCTION INTO BAYOU LAFOURCHE
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LEGEND

- DONALDSONVILLE ALTERNATIVES
- SMOKE BEND ALTERNATIVES

**FIGURE ES-8
COST-EFFICIENCY PLOT
SEVEN REMAINING ALTERNATIVES
BAYOU LAFOURCHE CHANNEL**

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Coordination of Project Activities with Other Stakeholders

Numerous key activities were defined for the project going forward into 30 percent design. Many of these activities involve coordination of the various aspects of the project with other stakeholders. A partial list of these activities and stakeholders is as follows:

- Refine the availability and suitability of dredged material for use in agricultural operations and beneficial reuse applications (marsh creation/nourishment) near the bayou.
- Refine the design criteria for crossing the levee along the Mississippi River with the U.S. Army Corps of Engineers and the Mississippi River Commission.
- Meet with representatives of the Louisiana Department of Transportation and Union Pacific Railroad to refine railroad crossing criteria for the project facilities.
- Gain concurrence on assumptions and parameters to be incorporated into the Wetlands Value Assessment with CWPPRA technical experts.
- Continue discussions with the Lafourche Freshwater District regarding operation and maintenance requirements and design configuration of the diversion pump stations.
- Continue drainage impacts research along the bayou, and refine the information currently available through ongoing contacts with appropriate city and parish officials.